BIG BIOMIMICRY CHALLENGE

A nature-inspired response to some of life's biggest challenges

AGE RANGE

13–15

DURATION

Preparation:
Varies (10–20 minutes)

Activity:
30–50 minutes per activity (three activities total).

KEYWORDS

Problem/challenge-based learning; group work; presentations; evaluation of designs

SUMMARY

This module takes students through the process of nature-inspired design, and a structured design task, involving individual and group work. The module is designed to stand alone, or as part of a large scheme of work. While many of the concepts are relevant to Design Technology and Biology, the module will also appeal to teachers looking to develop study skills including team work and presentation competences in students.

BIOMIMICRY PRINCIPLES

1 – Nature runs on sunlight
2 – Nature uses only the energy it needs
3 – Nature fits form to function
4 – Nature recycles everything
5 – Nature rewards cooperation
6 – Nature banks on diversity
7 – Nature demands local expertise
8 – Nature seeks balance
9 – Nature taps the power of limits

LEARNING OBJECTIVES

- Students understand that working with nature can help to address sustainability challenges.
- Students develop knowledge of a variety of sustainability challenges and how they affect society.
- Students develop their presentation skills, learn to give and receive feedback.
- Students engage with and discuss sustainability challenges, on a variety of scales.
- Students are able to apply biomimicry principles to address a design / challenge.

LEARNING OUTCOMES

- Students apply biomimicry principles to solve a design challenge.
- Students collaborate with others to solve problems as a group.
- Students engage with group work, presentations and feedback.
- Students make use of evaluation processes to improve their design.

SUBJECT(S)

This learning module can be used flexibly within the curriculum to support key knowledge about Biology and Design Engineering & Technology, and develop working scientifically competences. The learning links with the Sustainable Development Goals and provides a broader context for student learning. It is suitable for adapting as a STEM activity or Eco Club.

Programme of Study Reference	Working Scientifically
Depending on challenges identified by students, other areas of biology, chemistry and physics will be relevant. **Biology:** KS4 Ecosystems • some abiotic and biotic factors which affect communities; the importance of interactions between organisms in a community. • organisms are interdependent and are adapted to their environment. • the importance of biodiversity. • methods of identifying species and measuring distribution, frequency and abundance of species within a habitat. KS3 Interactions and interdependencies; Relationships in an ecosystem • the interdependence of organisms in an ecosystem, including food webs and insect pollinated crops. • how organisms affect, and are affected by, their environment, including the accumulation of toxic materials. Genetics and evolution; Inheritance, chromosomes, DNA and genes • differences between species. • the variation between species and between individuals of the same species means some organisms compete more successfully, which can drive natural selection. • changes in the environment may leave individuals within a species, and some entire species, less well adapted to compete successfully and reproduce, which in turn may lead to extinction. **Design, Technology and Engineering:** KS4 • Design and making principles (links with developing context for design, understanding factors affecting design, critical analysis and applying different design strategies). KS3 • Design (links with most areas). • Evaluate (links with most areas).	Students successfully completing this module will have had the opportunity to access these statements: **1d, 1e, 2a, 2g.** See Annex 1 for full statements.

BIOLEARN COMPETENCES

- Students are able to abstract principles of sustainability from the way the natural world functions.
- Students are able to identify functional design in Nature, develop greater awareness and appreciation for design excellence in Nature, and appreciate how nature works as a system which is elegant and deeply interconnected.
- Students are able to identify important needs and opportunities that can be addressed through design innovation for products, processes and systems.
- Students are able to use analogical creativity to innovate, using biological models to inspire solutions to design challenges.
- Students are able to assess the consequences of applying biomimicry solutions (values)
- Students are able to work in groups.

SUMMARY OF THE ACTIVITIES

	Activity Name	Description	Method	Duration	Location
1 (3)	Big biomimicry challenge	Identifying a challenge making use of biomimicry to help solve it	• Group work	50	Indoor/ Outdoor
2 (4)	Collaboration and group work	Use nature to help design a solution in a group	• Group work	50	Indoor/ Outdoor
3 (5)	Mini group presentations and feedback	Present ideas to other groups and adapt design based on feedback	• Presentations / Group work	50	Indoor

BACKGROUND FOR TEACHERS

This module takes students through the process of nature-inspired design, using a structured set of design tasks involving individual and group work. The module in large part follows the worksheet (W1.1). The module can be easily adapted to suit a range of time-allocations, and might be delivered in different arrangements – for example:

1. Lessons 1–2: Introduction to Biomimicry
2. Lessons 1–5: Introduction to Biomimicry + Biomimicry challenge

The module utilises accompanying presentations which contain detailed teaching notes, in order that different teaching staff can deliver each lesson. More straightforward teaching notes are included in this guide under each lesson/activity overview below.

During the lessons, students will become familiar with the terms function and strategy. It is important to be clear about these terms and we offer the following definitions:

Functions: In biomimicry a function refers to an organism's adaptations which help it survive. For example, the purpose of bear fur is to keep warm, in technical terms its function is to conserve heat (insulation). A leaf is made to biodegrade, so one function of a leaf is to 'break down' after use. Human products also have functions; a kettle has the functions to both contain water and heat water (modify its physical state). In brief, a function is 'what it does.'

Strategy: Organisms meet functional needs through biological strategies. This is a characteristic, mechanism or process which performs the function for them. In the bear example, fur is the strategy for delivering insulation. In a kettle, electrical energy is transferred into physical heat which modifies the temperature of water. In brief, a strategy is 'how it does it.'

Health and Safety
Appropriate consideration needs to be given to health and safety when working outdoors, but this should not prohibit regular use of the outdoor learning environment.

For guidance on using the outdoor learning environment review the Council for Learning Outside the Classroom suggestions on Plan and Deliver. CLEAPSS also provides guidance for members. We recommend you read and act on L196 – Managing Risk Assessment in Science. Finally, check your school policy on learning outside the classroom.

The Institute for Outdoor Learning provides a good overview into the risks and benefits of outdoor learning here. They also offer specific guidance and advice for schools here.

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS
pens, paper

PREPARATIONS
Classroom to be arranged for group work. Pens and paper available on each table.

RESOURCES
W1.1 – student worksheet;
W1.2 – design challenges;
W1.3 – biomimicry links and websites;

PowerPoint presentation

1 | BIG BIOMIMICRY CHALLENGE

» DISCOVER

This activity guides students through the process of identifying a challenge and making use of biomimicry and nature-inspired thinking to help solve the challenge. The accompanying worksheet (see: W1.1) takes students through a structured step-by-step process culminating in the development of a design as a solution to their challenge. This activity prepares the students for the following two activities which encourage collaboration and discussion.

1.1 CHOOSE A PROJECT (#1 on student worksheet W1.1)

Students will need to use the principles of biomimicry to come up with an innovative solution to a design challenge of their choice.

Working in groups of 3–4, choose an existing design challenge from W1.2 (three to choose from – teachers may wish to reduce this number to suit the group); also detailed in accompanying PowerPoint Slides 4–6.

Prompt students to read through each problem and think carefully about each one as they will be only choosing one of these to solve in their group.

The Sustainable Development Goals (SDG's) are global goals which provide a focus for development, design and innovation which enables both people and the planet to thrive. Most problems (and solutions) can link to at least one SDG. The 17 SDGs are listed below. Ask students to read through them (see PowerPoint Slide 7) and write down the 3 goals that are the most important to them.

1.2 MY DESIGN CHALLENGE (#2 on student worksheet W1.1)

For the chosen challenge, students follow the process below to help them to focus their design.

Students follow the worksheet W1.1 to:

- Give a simple explanation of what you want their design to achieve or do (see prompts on worksheet).
- Describe some of the factors (e.g. location, resources, and users) that are important to consider.
- Using the information above, students phrase their challenge as a question. Remind them to be careful to clearly describe different elements if necessary. e.g. How might we make urban cyclist more visible to drivers at night?

1.3 HOW WOULD NATURE...? (#3 on student worksheet W1.1)

Next, help students to consider how nature might solve this. To begin with, prompt them to turn their 'how might we' question into a simpler 'how would nature' question. Fill in responses on the worksheet.

For example, rather than asking "How does nature make cyclists more visible at night?" we ask "How does nature enhance visibility in low light conditions?" This simplified question expresses what the design is trying to do.

If students require help or inspiration, give them sheet W1.3 which contains useful links and websites.

OPTIONAL: HOMEWORK TASK

To help prepare students for the next lesson, they can look for functions in nature which relate to their challenge. They can use the table #4 in W1.1 for this task. Begin by listing the functions which they need, and then look outside for examples of where nature achieves these functions.

LOCATION
Indoor / Outdoor

TOOLS AND MATERIALS

paper, pens

PREPARATIONS

Classroom to be arranged for group work. Pens and paper available on each table.

RESOURCES

W1.1 – student worksheet

2| COLLABORATION AND GROUP WORK

» CREATE

In this activity students start to apply biomimicry approaches to problem solving by looking to nature for inspiration. To achieve this, they are prompted to consider the functions that nature provides, and think how this might be applied to their own challenge. Students continue to work through the worksheet W1.1 in groups, and conclude the activity by sketching and labeling their design, in preparation for the next activity.

2.1 USING INSPIRATION FROM NATURE (#4 on student worksheet W1.1)

Remind students of their main challenge / problem (see # 1 on W1.1), and ask them to look over answers to #3 on W1.1. Ask them to think about the function they want to achieve, where in nature you might find this function, and then think about how this might be applied to their challenge.

Students work in groups to fill in the table in the worksheet to identify the function, consider where this might be found in nature, and think about applying it to their challenge. Provide students with W1.3 which contains useful links and websites.

2.2 SKETCH (#5 on student worksheet W1.1)

Students sketch out their design – use imagination to think about what it might look like. Annotate and label it. Use the space provided on the worksheet.

ACTIVITY DETAILS

LOCATION
Indoor

TOOLS AND MATERIALS

paper, pens

PREPARATIONS

Classroom to be arranged for group work. Pens and paper available on each table.

RESOURCES

W1.1 – student worksheet; W3.1 – biomimicry principles; W3.2 – improving your design; W3.3 – feedback evaluation wheel.

3 | MINI GROUP PRESENTATIONS AND FEEDBACK

» CREATE

In this activity, students form new groups in order to present their design, and its underlying nature-inspired problem solving to others. The task involves both presenting and listening, concluding with a chance to adapt the designs based on feedback, and an opportunity to consider the future based on their designs.

3.1 DISCUSSION IN PAIRS

Ask students to:

- Discuss your sketch from last lesson with your partner
- Describe and explain your design
- Discuss how nature helped you come up with your design?

Provide students with W3.1 and W3.2.

Students use the biomimicry principles (W3.1), alongside the evaluation wheel and associated questions on worksheet (W3.2) to evaluate their design. See PowerPoint Slides 10–12.

3.2 GROUP COLLABORATION (#6 on student worksheet W1.1)

- Each member of the group should have a copy of the sketch/ design.
- Students get into groups of 3–4 with members of different groups (there should not be two people from the same group in the 'new groups'). Each student takes a copy of the feedback evaluation wheel (W3.3).
- Students take it in turns to explain their design to the 'new group'. Following each presentation, the group together fills in W3.3 for the student who presented.

When presenting to the new group, students should aim to answer the following questions (you may wish to provide them with five minutes of preparation time before forming groups):

- What was your design challenge?
- Why did you choose this design challenge?
- Which aspect of biomimicry aided you in your design?
- How does your design solve the challenge you chose?

EXTENSION

Following the collaborative presentations, provide students with time to return to their original groups and adapt their design based on their collaboration. They might use the evaluation wheel to help them with this.

Based on the design solutions, ask students to consider what the future will look like in 30 years. You can ask students to answer this question on a local, national and international scale. Can this be linked back to the Sustainable Development Goals in Activity 1.1? Students discuss this in their groups for 5 minutes.

Some follow up questions:
- How do the designs you have seen in the lesson today link to the sustainable development goals?
- Do you think sustainable development is possible?
- How could the use of biomimicry enable us to come up with sustainable solutions to development?

How could biomimicry act as a tool for thinking and planning for the future of our planet?

LITERATURE, ADDITIONAL INFORMATION

Below are a range of useful website links and book references.

WEBSITES
Ask Nature – https://asknature.org/
The key resource for exploring biomimicry examples; a rich resource to delve in to. Their resources area (https://asknature.org/?s=&p=0&hFR%5Bpost_type_label%5D%5B0%5D=Resources) offers teaching resources, videos and articles to explore.

Biomimicry Toolbox – https://toolbox.biomimicry.org/
Great resources explaining the core concepts of biomimicry and a step-by-step approach to applying a biomimicry approach to design.

Packaging Innovation Toolkit – https://synapse.bio/blog/2017/10/11/biomimicry-packaging-innovation-toolkit
Resources to expand ideas around packaging based on biomimicry thinking.

Genius of Place – https://synapse.bio/blog/ultimate-guide-to-genius-of-place
In the Genius of Place process, biomimics look to native organisms and ecosystems to provide guidance, models, and metrics for how to be generous and resilient as we design for a particular place.

ACTIVITY DETAILS

BOOKS & JOURNALS

Biomimicry Resource Handbook

The key resource for biomimicry thinking, processes and applications. A huge amount of information and ideas; expensive but well worth it.

Baumeister, Dayna (2014). *Biomimicry Resource Handbook 2014: A Seed Bank of Best Practices*. Biomimicry 3.8.

Biomimicry: Innovation Inspired by Nature

The book by Janine Benyus which first brought biomimicry to wide attention. Lots of good examples to use and descriptions of the nine principles of biomimicry.

Benyus, Janine (2002). *Biomimicry: Innovation Inspired by Nature*. HarperCollins.

Zygote Quarterly

Showcases examples of science, technology and creativity in the field of biologically inspired design.

https://biomimicry.org/zygote-quarterly/

- W1.1 designed either as standalone worksheets or as a workbook for students to keep and bring to each lesson. We recommend this is printed as an A4 workbook.

- Three design challenges are provided as starting point, but teachers should feel free to adapt these to local circumstances, add to them, or reduce the number to choose from.

W1.1 MY BIOMIMICRY CHALLENGE

1. CHOOSE A PROJECT
Working in groups of 3–4, choose a design challenge (three to choose from).

HINT: You might like also to have a look in the local press for an issue which interests you.
Q: What is your challenge?

. . . .

. . . .

. . . .

Sustainable Development Goals
The Sustainable Development Goals (SDG's) are global goals which provide a broad focus for development, design and innovation which enables both people and planet to thrive. Most problems (and solutions) can link to at least one SDG.

For your chosen area of interest use the diagram below and circle up to 3 SDG's which link to your challenge.
Which SDGs does your challenge link with?

Q: How do these goals link with your chosen challenge? Make some notes here:

. . . .

. . . .

. . . .

2. MY DESIGN CHALLENGE

For your challenge, follow the process below to help you to focus your design.

a. Frame your challenge

Give a simple explanation of what you want your design to achieve or do by completing the following:
The challenge my design will solve is... (add a description of the problem)

. . . .

. . . .

. . . .

To solve this challenge, my design will... (describe what you design will do to solve the problem)

. . . .

. . . .

. . . .

b. Consider the context

Describe some of the factors (e.g. location, resources, and users) that are important to consider.

. . . .

. . . .

. . . .

. . . .

c. Design a question

Using the information above, phrase your challenge as a question. Be careful to clearly describe different elements if necessary. e.g. How might we make urban cyclist more visible to drivers at night?

How might we . . . .

. . . .

. . . .

. . . .

. . . .

The following online resources might help you:
Five tips and suggestions to help you can be found here:
https://toolbox.biomimicry.org/methods/biologize/
https://thekidshouldseethis.com/?s=nature+based+solutions
https://thekidshouldseethis.com/?s=circular+economy
Ask Nature: https://asknature.org/

3. HOW WOULD NATURE...?

Now that you have identified and focused in on a challenge to work on, have a go at thinking about how nature might solve this. To begin with, turn your *'how might we'* question into a simpler *'how would nature'* question.

For example, rather than asking "How does nature make cyclists more visible at night?" we ask "How does nature enhance visibility in low light conditions?" This simplified question expresses what the design is trying to do.

Using **2c** as a starting point, add some questions below, beginning with *'how would nature...'*:

1. How would nature . . . .
2. How would nature . . . .
3. How would nature . . . .

4. USING INSPIRATION FROM NATURE

Remind yourself of your main challenge / problem (see Question 1), and look over your answers to Question 3. Think about the function you want to achieve, where in nature you might find this function, and then think about how this might be applied to your challenge.

Function	Ask Nature	Apply
What do you want to do? HINT: think about smaller pieces of the challenge first.	**Where might you find this in nature? How does nature do this?**	**How can nature help you address your challenge? What can you borrow from nature, and how might it be applied in this context?**
EXAMPLE: Enhance visibility in low light.	Cat's eyes have a layer of reflective cells at the back which reflects low levels of light.	Can the form and function of the cells be mimicked to improve the design of cyclists' reflective clothing?
EXAMPLE: Provide warmth in cold weather.	Bears fur traps warm air close to the skin, insulating it against cold winter temperatures.	Can we design a jacket which traps warm air for insulation?
EXAMPLE: Eliminate waste.	In nature waste from one process is food for another; trees shed their leaves to conserve energy over winter and these leaves decay to provide nutrients for soil micro-organisms.	Can we design plastic bottles so once finished with they can 'feed' another process or be completely reused?

5. SKETCH

Now you are equipped with nature's inspiration, use the space below to plan, sketch and draw your idea. Use your imagination to consider how it might look and work. Add labels and annotations in the space around the edge so that others can see what you have in mind!

6. GROUP COLLABORATION

In this exercise you will form new groups – consisting of a member from each of your original group. You will take it in turns to present your design to the new group.

- Each member of the group should have a copy of the sketch/ design.
- Get into groups of 3–4 with members of different groups; there should not be two people from the same group in the 'new groups.'
- Take it in turns to explain you design to the 'new group' – see questions below.

When presenting to the new group, the presenter should aim to answer the following questions. Make some notes beforehand below:

What is your design challenge?

....

....

Why have you chosen this design challenge?

....

....

Which aspect of biomimicry aided you in your design?

....

....

How does your design solve the challenge you chose?

....

....

Reflection

If your designs were all put into action or made, how might it positively improve your community, region, country in the future?

Discuss with your group and note the key points below.

....

....

....

Let's get thinking! *How could biomimicry act as a tool for thinking and planning for the future of the planet upon which we depend?*

W1.2 DESIGN CHALLENGES

6 CLEAN WATER AND SANITATION

PROJECT OPTION 1: WATER USE AND EFFICIENCY

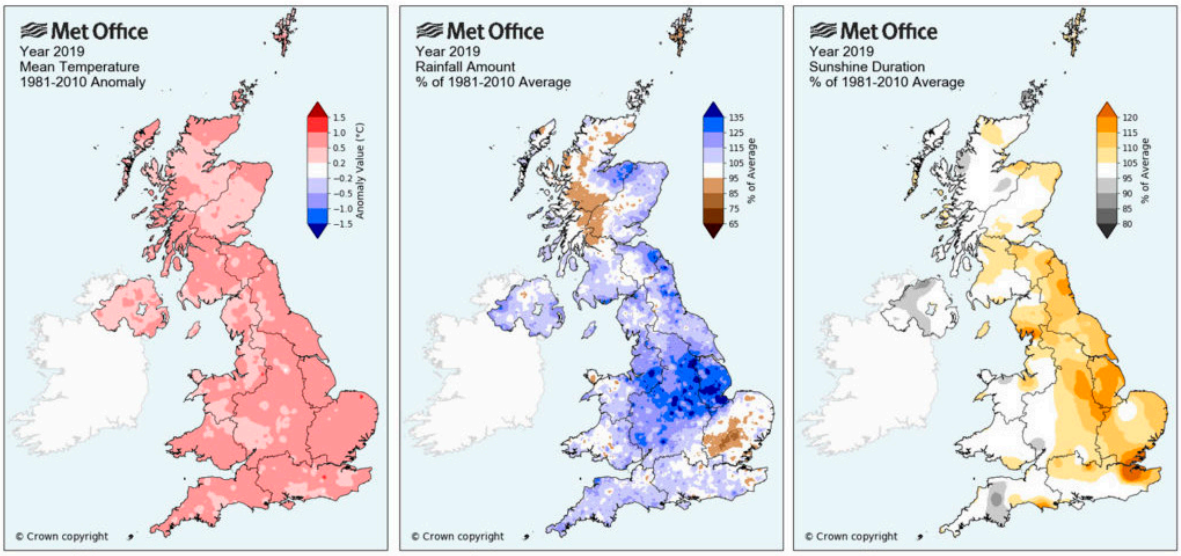
ISSUE: During times of drought we face water shortages and this is set to get worse with climate change.

CHALLENGE: Design a system for collecting water when it rains and storing it for times of drought.
Come up with a solution to this problem, through a design or idea, using nature to help you.
Some things to focus on include: water collection; water filtration; purification; distribution; efficient use of water; reusing wastewater.

USE NATURE TO HELP: How does nature do these things? Are there examples from nature we can copy?

How does nature collect, store, filter and transport water?

News article here: https://www.carbonbrief.org/guest-post-a-met-office-review-of-the-uks-weather-in-2019
"Last year was warmer, wetter and sunnier than average for most of the UK, and finished as the 11th warmest, 11th wettest, and 15th sunniest year on record."



12 RESPONSIBLE CONSUMPTION AND PRODUCTION

PROJECT OPTION 2: RESPONSIBLE CONSUMPTION AND PRODUCTION

ISSUE: We are producing vast quantities of wase from packaging of goods.

CHALLENGE: How can we package goods using fewer and eco-friendly materials, while reducing and re-cycling wase?
Come up with a solution to this problem, through a design or idea, using nature to help you.
Some things to focus on include: packaging and materials, turning waste to resources.

USE NATURE TO HELP: How does nature do these things? Are there examples from nature we can copy?

How does nature create protection from damage and dirt, store things, and cycle wase into a resource?

11 SUSTAINABLE CITIES AND COMMUNITIES

PROJECT OPTION 3: DINING HALL CHALLENGE

ISSUE: The school canteen needs updating. It needs to serve multiple functions (e.g. social, eating, meeting, working, play) and be sustainable and a beautiful pleasant place to be.

CHALLENGE: How can we use nature to help us to redesign this space? How can we create a dining space to fulfil multiple functions while not relying on scarce materials.

Some questions you might like to focus on:

- Can you think of a good way to encourage *social interaction* in this space? (How does nature share space?)
- What would be a good way of *cooling and heating* this space? (How does nature keep structures warm/cool?)
- How does food, energy, water, etc. move in and out of the space – where does it come from and where does it go? *Flows and cycles.*
- Materials – How does nature create *sustainable materials* without mining?

W1.3 STUDENT RESEARCH LINKS

Starting points for resarching your challenges:

How does nature encourage social behaviour and efficient use of space?

- Bees and hexagons (space efficiency) – https://thekidshouldseethis.com/post/why-do-honeybees-love-hexagons

How does nature heat and cool spaces?

- Microclimates in burrows – https://www.desertmuseum.org/books/nhsd_adaptations_birds.php
- Termite mounds and Zebra Stripes – https://ecolutionalert.wordpress.com/2016/10/13/natural-air-conditioning/

How does nature make strong structures?

- Sea urchins prevent cracking and breaking – https://asknature.org/strategy/sea-urchin-shell-effectively-prevents-cracking-and-breaking/
- Making cement the way that coral does – https://www.youtube.com/watch?v=fa96YaJCTVc

How does nature collect and store water?

- Webs which collect water from clouds – https://asknature.org/strategy/web-continuously-collects-water-from-air/

You can look up more articles and videos on these websites:

- https://thekidshouldseethis.com/
- https://asknature.org/

TIP: Try searching for key words linked to your challenge.

W3.1 BIOMIMICRY PRINCIPLES

Introducing the principles

Janine Benyus describes biomimicry as "learning to live gracefully on this planet by consciously emulating life's genius. It's not really technology or biology; it's the technology of biology. It's making a fibre like a spider, or lassoing the sun's energy like a leaf." Designing for sustainability is also important to biomimicry thinking.

It's this kind of thinking that's inspired some remarkable designs in recent decades, including a Japanese bullet train partially modelled after the aerodynamics of the kingfisher bird; a shopping center in Harare, Zimbabwe that mimics the cooling strategies of a termite mound; and a synthetic surface called Sharklet that inhibits bacterial growth through texture alone, inspired by the bacteria-repellent skin of a shark.

Here are the **nine Basic Principles of Biomimicry** that we are working with. They are very simple, but once you unpack them you discover they lead everywhere. It is possible to use these principles as starting points for design, or as a way of checking our design work and then making improvements.

Nature runs on sunlight
Nature uses sunlight as the main source of energy. Organisms use heat and UV radiation from this never-ending source. We can say that nature is powered by sunshine. Humans use fossil fuels, these sources are not renewable, and burning them creates CO_2 which is one of the gases causing climate change. Why don't we do the same and prevent the climate crisis? A wise person would mimic nature and rely on renewable power.

Nature uses only the energy it needs
Nature takes only what it needs. Why do we not do the same? Our economy is focused on maximizing output and is a big energy consumer. We transport food around the world because that is economically cheaper. Only money seems to count in a lot of decisions, not energy consumption and impact on the natural world. How can we learn to optimize the performance of goods and services to sip energy rather than gulp it?

Nature fits form to function
A tree is rooted in the ground to draw water and nutrients from the soil; it spreads its branches and leaves wide to increase surface area and absorb sunlight to produce energy and grow. Seeds are lightweight and some even come equipped with a sort of umbrella so they can float in the air. Nature creates designs for the function they provide, so should our buildings, transportation systems and schools.

Nature recycles everything
There is no 'away' to throw things. Everything produced in nature is biodegradable, there is no waste. There can still be abundance, look at all the blossom on a cherry tree; but that all serves a purpose and will be food and nutrients for others. Once the natural life of a pinecone has come and gone, it breaks down into essential elements that are repurposed into new life.

Nature rewards cooperation
We see competition in nature, but only when it is impossible to avoid; in general competition costs too much energy. On the other hand, very little in nature exists in isolation. Plants cooperate with pollinators to disperse seeds, and the pollinators feed on nectar. Ladybirds feed on aphids and help plants to stay healthy. Nature favours cooperation because it maintains the health of the whole system.

Nature banks on diversity
Diversity is one of nature's best insurance policies. When one food source is unavailable, others can be found. Plants use several different strategies to spread seed or defend against predators. We know that species with limited genetic diversity have more difficulty adapting to environmental change, and that ecosystems rich with diversity are more stable.

Nature demands local expertise
Nature's systems are inherently local. Certain species thrive under specific conditions; local and regional weather patterns matter, as do other conditions such as soil, air quality and water temperature. Relationships are created locally and local resources are used. Of course, some birds travel long distances but have you seen them take their food with them?

Nature seeks balance
Ecosystems try to keep in balance. More mice? Then you will see more owls to feed on the mice and keep the population in balance. Forest fires are a great example of a natural phenomenon that renews and refreshes, reducing excessive growth and allowing for regeneration. Every natural system has a tipping point, a carrying capacity or a state of disequilibrium that triggers a change to a different state.

Nature taps the power of limits
Unlimited growth on a finite earth is not a good idea. All living things are governed by limitations; age, climate, population density and many other factors determine how species and systems develop. Nature has found ingenious ways to work within these limits to be as productive as possible over the long run.

W3.2 IMPROVING YOUR DESIGN

Group Evaluation Wheel and Questions

Improving your design
Consider how you might use the nine principles of biomimicry to improve your design. How might nature go about designing the product or function you are trying to produce?

DESIGN OR PROJECT NAME: ....

DESIRED FUNCTION / CONCEPT: ....

Q1: Based on the nine principles of biomimicry, this is close to how nature would design this product/project.

STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE

Q2: Looking at your design and comparing it to the nine principles of biomimicry, which areas are the strongest? **Why is this the case?**

....

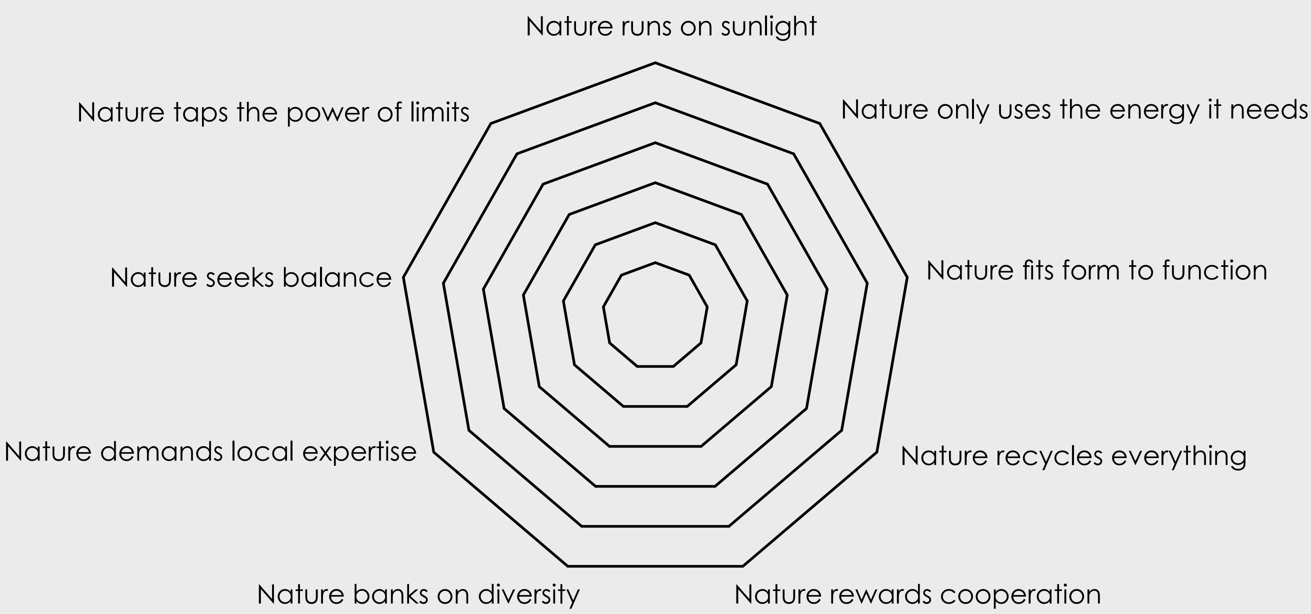
Q3: Which areas are the weakest? **Why is this the case?**

....

Q4: Think of one practical way you can improve your design.

....

TASK: Use the diagram below to plot how your product achieves in relation to each biomimicry principle of design. Use this to consider the strengths and weaknesses of your design.

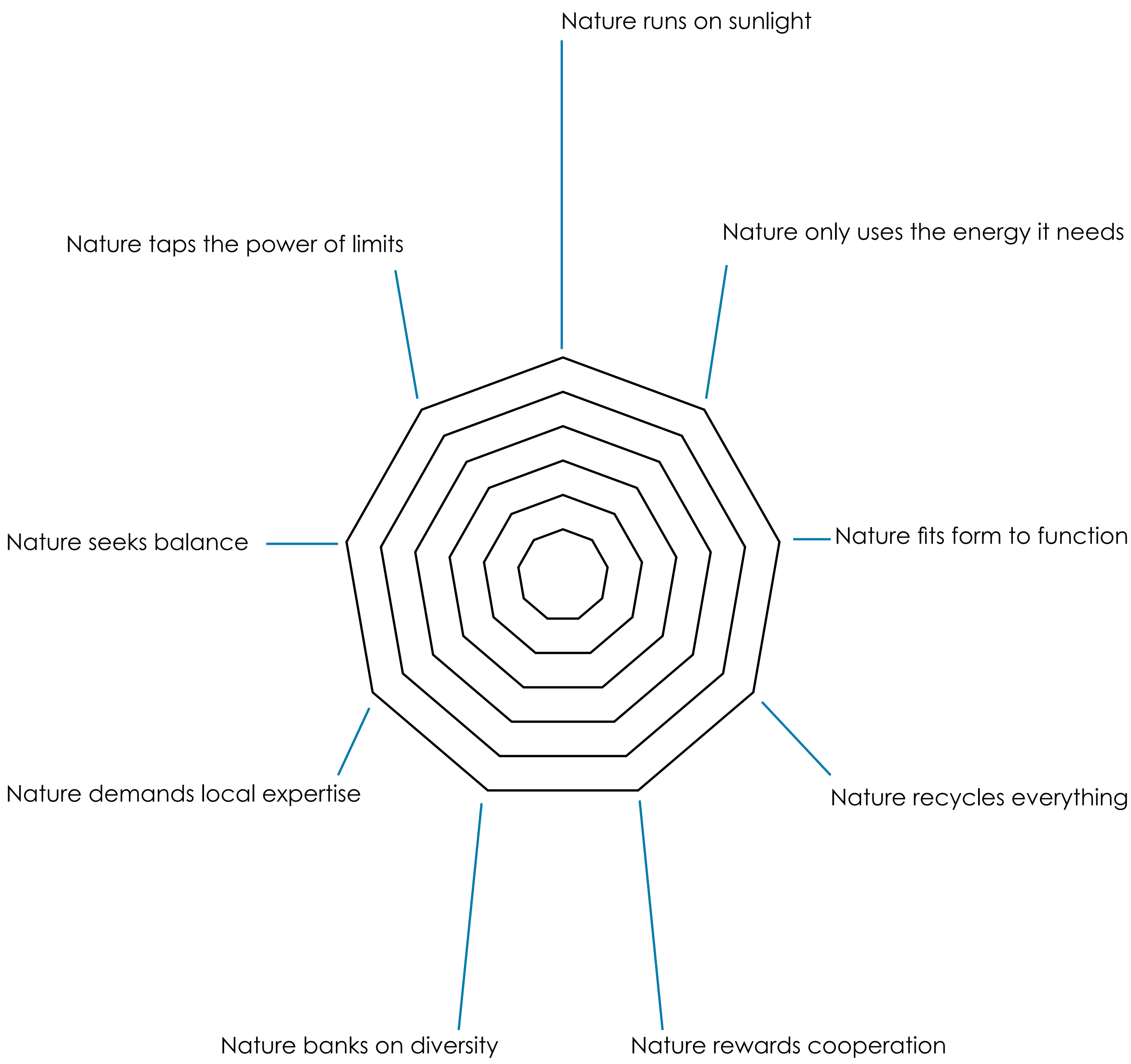


W3.3 FEEDBACK EVALUATION WHEEL

Evaluation of Design Presentations

NAME / DESIGN: ....

HINT: Make notes on the diagram below to collect feedback given during presentations so that you can improve your design.



ANNEX 1

Key Stage 4 Working Scientifically Statements

Through the content across all three disciplines, students should be taught so that they develop understanding and first-hand experience of:

1. THE DEVELOPMENT OF SCIENTIFIC THINKING	a. the ways in which scientific methods and theories develop over time b. using a variety of concepts and models to develop scientific explanations and understanding c. appreciating the power and limitations of science and considering ethical issues which may arise d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments e. evaluating risks both in practical science and the wider societal context, including perception of risk f. recognising the importance of peer review of results and of communication of results to a range of audiences
2. EXPERIMENTAL SKILLS AND STRATEGIES	a. using scientific theories and explanations to develop hypotheses b. planning experiments to make observations, test hypotheses or explore phenomena c. applying a knowledge of a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments d. carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations e. recognising when to apply a knowledge of sampling techniques to ensure any samples collected are representative f. making and recording observations and measurements using a range of apparatus and methods g. evaluating methods and suggesting possible improvements and further investigations
3. ANALYSIS AND EVALUATION	a. applying the cycle of collecting, presenting and analysing data, including: i. presenting observations and other data using appropriate methods ii. translating data from one form to another iii. carrying out and representing mathematical and statistical analysis iv. representing distributions of results and making estimations of uncertainty v. interpreting observations and other data, including identifying patterns and trends, making inferences and drawing conclusions vi. presenting reasoned explanations, including relating data to hypotheses vii. being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility and identifying potential sources of random and systematic error b. communicating the scientific rationale for investigations, including the methods used, the findings and reasoned conclusions, using paper-based and electronic reports and presentations

4. VOCABULARY, UNITS, SYMBOLS AND NOMENCLATURE	a. developing their use of scientific vocabulary and nomenclature b. recognising the importance of scientific quantities and understanding how they are determined c. using SI units and IUPAC chemical nomenclature unless inappropriate d. using prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano) e. interconverting units f. using an appropriate number of significant figures in calculations